

Notice No.1

Rules for the Manufacture, Testing and Certification of Materials, July 2022

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: December 2022

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Chapter 1, Sections 4, 5 & 6	1 January 2023	1 January 2023
Chapter 2, Sections 1, 2, 3, 4 & 10	1 January 2023	1 January 2023
Chapter 3, Sections 1, 6, 7 & 8	1 January 2023	1 January 2023
Chapter 4, Sections 1, 2, 3, 4 & 8	1 July 2023	1 July 2023
Chapter 5, Sections 1, 2, 3, 5 & 9	1 July 2023	1 July 2023
Chapter 6, Sections 1, 4 & 5	1 January 2023	1 January 2023
Chapter 9, Section 1	1 January 2023	1 January 2023
Chapter 10, Sections 1 & 2	1 January 2023	1 January 2023
Chapter 12, Sections 2, 4 & 7	1 January 2023	1 January 2023
Chapter 13, Section 4	1 January 2023	1 January 2023
Chapter 13, Section 8	Corrigendum	N/A
Chapter 14, Sections 2 & 3	1 January 2023	N/A
Chapter 15, Section 2	1 January 2023	N/A



Chapter 1

General requirements

■ Section 4

General requirements for manufacture

4.3 Heat treatment

4.3.2 Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole item to be uniformly heated to the necessary temperature. In the case of very large components which require heat treatment, alternative methods will be specially considered. Furnace temperature uniformity surveys to recognised standards (e.g. ASTM A991/A991M) shall be carried out at the specified frequency.

■ Section 5

Non-destructive examination

5.12 Digital radiography

(Part only shown)

5.12.3 All examinations utilising RT-D methods are to be undertaken using an approved procedure. In addition to the general procedural requirements, as specified in [Ch 13, 2.12 Non-destructive examination of steel welds](#) instructions, procedures for RT-D shall conform to, and specify the following requirements (where applicable):

- (a) Technical requirements concerning digital radiography are to be based on ISO 17636-2:2013 and standards referenced therein, or other recognised standards acceptable to LR (upon agreement).

■ Section 6

References

6.1 General

(Part only shown)

Table 1.6.1 List of National standards

Rule reference	Standard
Chapter 1- General requirements	ASTM A991/A991M
Chapter 2- Testing Procedures for Metallic Materials	~~ISO 185~~ ISO 2566-1 ~~ISO 2566-2~~ ISO 148-1 ~~ISO 148-2~~ ISO 7500-1 ~~ISO 6508-1~~ ~~ISO 8492~~ ISO 8493 ISO 8494 ~~ISO 8495~~ ASTM E23 ~~ASTM E208~~ ~~ASTM A770/A770M~~ EN 10164
Chapter 3 - Rolled Steel Plates, Strip, Sections and Bars	~~ASTM A578-07~~ ~~ASTM E381-01~~ ISO 7452 ~~ASTM E208-06~~ ~~ASTM A770/A770M~~ ISO 643 ~~JWES2815~~ ASTM E45 ~~EN 10163-1~~ ~~EN 10163-2~~ ~~EN 10163-3~~ EN 10164
Chapter 4- Steel Castings	ASTM A991/A991M

	ISO 683-1 ISO 683-2 ISO 148-1 ISO 4990
Chapter 5- Steel Forgings	ASTM A991/A991M ASTM A745/A745M ISO 148-1 EN 10228-4
Chapter 8 - Aluminium Alloys	ASTM G67 ASTM B928
Chapter 9 - Copper Alloys	EN 1057:2006 +A1
Chapter 10 - Equipment for Mooring and Anchoring	BS 7160 ASTM E381-01
Chapter 13 - Requirements for Welded Construction	ISO 10042 ISO 11666
Chapter 14 - Plastics Materials	ASTM C273/C273M ASTM C393/C393M ASTM D2583-13a BS 1088 ISO 175 BE-EN 59

Chapter 2

Testing Procedures for Metallic Materials

■ Section 1

General requirements for testing

1.2 Testing machines

1.2.3 Impact tests are to be carried out on Charpy V-notch machines calibrated to ISO 148-2 or ASTM E23 dependent on the testing machine type. The testing machines are to be calibrated using either a direct or indirect method. Other National Standards equivalent to ISO 148-2 may be considered.

■ Section 2

Tensile tests

2.1 Dimensions of test specimens

2.1.14 Through thickness tensile test specimens may be, at the option of the steelmaker, either plain test specimens, or test specimens with welded extensions, in accordance with a Recognised Standard such as EN 10164 or ASTM A770/A770M.

2.3 Procedure for testing at ambient temperature

2.3.1 Except as provided in [Ch 2, 2.3 Procedure for testing at ambient temperature 2.3.5](#), the elastic stress rate for the determination of the upper yield for steels and copper alloys is to be between 6 and 60 N/mm² per second and between 2 and 20 N/mm² per second for aluminium and copper alloys. After reaching the yield or proof load, the straining rate may be increased to a maximum of 0,008s⁻¹ for the determination of the tensile strength.

2.3.5 For the determination of the tensile strength of flake graphite cast iron, the stress-strain rate is not to exceed 10 N/mm² 0,0067 per second.

2.4 Equivalent elongations

2.4.4 For non-proportional test specimens with gauge lengths of 50 mm and 200 mm, the equivalent elongation values tabulated in ISO 2566-1 are to apply. For Austenitic steels, conversion of room temperature percentage elongations after fracture obtained on various proportional and non-proportional gauge lengths to other gauge lengths shall be in accordance with ISO 2566-2.

■ Section 3 Impact tests

3.2 Testing procedures

3.2.2 Charpy V-notch impact tests may be carried out at ambient or lower temperatures in accordance with the specific requirements given in subsequent Chapters of these Rules. Where the test temperature is other than ambient, the temperature of the test specimen is to be controlled to within $\pm 2^{\circ}\text{C}$ for sufficient time to ensure uniformity throughout the cross-section of the test specimen, and suitable precautions are to be taken to prevent any significant change in temperature during the actual test. In cases of dispute, ambient temperature is to be considered as ~~18°C to 25°C~~ $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ consistent with ISO 148-1.

■ Section 4 Ductility tests for pipes and tubes

4.2 Flattening tests

4.2.1 Ring test specimens are to be cut with the ends perpendicular to the axis of the pipe or tube. The length of the specimen is to be equal to 1,5 times the external diameter of the pipe or tube, but is to be not less than 10 mm or greater than 100 mm. Plain and smoothed ends cut perpendicular to the tube axis are to be in accordance with ISO 8492. Alternatively, the length of the test specimen may be 40 mm irrespective of the external diameter.

4.3 Drift expanding tests

4.3.3 Testing is to be carried out at ambient temperature and is to consist of expanding the end of the tube symmetrically by means of a hardened conical steel mandrel having a total included angle of 30° , 45° or 60° , see [Figure 2.4.1 Drift expanding test](#). The lengths of the drift expanding test specimens are to be in accordance with ISO 8493. The mandrel is to be forced into the test specimen at a rate not exceeding 50 mm/min until the percentage increase in the outside diameter of the end of the test specimen is not less than the value given in the specific requirements for boiler and superheater tubes, see [Ch 6 Steel Pipes and Tubes](#). The mandrel is to be lubricated, but there is to be no rotation of the tube or mandrel during the test. The expanded portion of the tube is to be free from cracks or other flaws.

4.4 Flanging tests

4.4.1 The test specimens are to be cut with the ends perpendicular to the axis of the tube. The length of the specimens is to be at least equal to the external diameter of the tube and such that after testing the portion that remains cylindrical is not less than half the external diameter. The edges of the end to be tested may be rounded by filing. The flanging test specimen is to be of length equal to approximately 1,5 times the original outside diameter of the tube. The test piece may be shorter provided that after testing the remaining cylindrical portion is not less than 0,5 times the original outside diameter of the tube.

4.4.2 Testing is to be carried out at ambient temperature and is to consist of flanging the end of the tube symmetrically by means of hardened conical steel mandrels. The rate of flanging is not to exceed 50 mm/min in accordance with ISO 8494.

4.5 Ring expanding test

4.5.1 The test piece consists of a ring having a length of between 10 mm and 16 mm. The test piece shall be taken from the ends of deburred tubes as manufactured before they are cut to length. The rate of penetration of the mandrel shall not exceed 30 mm/s consistent with ISO 8495.

■ Section 10 Drop weight tests

10.1 Drop weight test specimens

10.1.1 Drop weight specimens for the determination of no-break performance are to comply with ASTM E208 and have one of the following dimensions (mm):

Type P-1: 25×90×360

Type P-2: 19×50×130

Type P-3 : 16×50×130

10.1.2 If not otherwise specified:

- the specimen sides shall be saw-cut or machined (minimum 25 mm to flame-cut surface)
- the machining of the plate to prescribed specimen thickness shall be on one side only

- the specimens may be of any orientation, but the orientation shall be the same for all specimens.

Chapter 3

Rolled Steel Plates, Strip, Sections and Bars

■ Section 1

General requirements

1.5 Surface quality of materials

1.5.1 The steel is to be free from surface defects prejudicial to the use of the material for the intended application. The finished material is to have a surface quality in accordance with a recognised standard such as EN 10163 parts 1, EN 10163-2 and EN 10163-3 or an equivalent standard accepted by LR, unless otherwise specified in this Section.

■ Section 6

Carbon-manganese and nickel alloy steels for low temperature service

6.4 Mechanical tests

(Part only shown)

Table 3.6.3 Mechanical properties for acceptance purposes (see Note 1)

Grade of steel	Yield stress N/mm ² min	Tensile strength N/mm ²	Elongation on $5.65\sqrt{S_0}$ % min (see Note 3)	Charpy V notch impact tests (see Note 32)	
				Test temp °C	Impact energy
Note 23. See Ch 3, 1.9 Test material and mechanical tests 1.9.11					
Note 3. For full thickness tensile test specimens with a width of 25 mm and a gauge length of 200 mm (see Figure 2.2.4 Test specimen dimensions for plates, strip and sections - II in Ch 2 Testing Procedures for Metallic Materials) the minimum elongation is to be:					

Thickness t , mm		$t \leq 5$	$5 < t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$	$t > 50$
Elongation	Strength levels	14	16	17	18	19	20	21	22	To be specifically agreed
	27S, 32									
	Strength levels	13	15	16	17	18	19	20	21	
	36									
	Strength levels	12	14	15	16	17	18	19	20	
	40									

■ Section 7

Austenitic and duplex stainless steel

7.1 Scope

7.1.1 Provision is made in this Section for rolled products in austenitic and duplex (austenite plus ferrite) stainless steels intended for use in the construction of marine equipment such as cargo tanks, storage tanks and process pressure vessels for chemicals and liquefied gases.

7.1.2 Austenitic stainless steels are suitable for applications where the lowest design temperature is not lower than -165°C .

7.1.4 Duplex stainless steels are suitable for applications where the lowest design temperature is not lower than -20°C, above 0°C. Any requirement to use duplex stainless steels below 0°C will be subject to special consideration.

7.1.5 Duplex stainless steels are also suitable for service at temperatures up to 300°C, and for such applications the proposed specification should include, in addition to the requirements of 7.1.6 [Ch 3, 7.1 Scope 7.1.6](#), a minimum value for 0,2 per cent proof stress at the design temperature.

7.1.6 ~~A specification giving details of the~~ Where it is proposed to use alternative steels, particulars of the specified chemical composition, heat treatment and mechanical properties, including, for the austenitic grades, both the 0,2 and 1,0 per cent proof stresses, is to be submitted for consideration and approval.

7.4 Mechanical tests

7.4.2 For the duplex grades, one set of three Charpy V-notch impact test specimens machined from the longitudinal direction for each tensile test is to be tested at -20°C or 5°C below the design temperature, whichever is lower. The average energy value of the three specimens is to be not less than 41 Joules.

7.9 Certification of materials

7.9.1 At least two copies of each test certificate are to be provided. They are to be of the type and give the information detailed in [Ch 3, 1.13 Certification of materials](#) and, where applicable, the results obtained from corrosion tests, and sigma phase assessment. Additionally, the specified maximum carbon equivalent is to be stated. As a minimum, the chemical composition is to include the contents of any grain refining elements used including and of the residual elements, as detailed in [Table 3.7.1 Chemical composition](#).

■ Section 8 Plates with specified through thickness properties

8.3 Test material

8.3.2 For plates and wide flats, one test sample is to be taken close to the longitudinal centreline from one end of each rolled piece representing the batch, see [Table 3.8.1 Batch size dependent on product and sulphur content](#) and [Figure 3.8.2 Plate and wide flat sampling position](#). The test sample must be large enough to accommodate the preparation of 6 specimens. 3 test specimens are to be prepared while the rest of the sample is to be retained for possible retests. The test specimens shall be located in the mid-thickness region of the plate prepared in accordance with a recognised standard, e.g. EN 10164 or ASTM A770/A770M.

Chapter 4 Steel castings

■ Section 1 General requirements

1.1 Scope

1.1.3 As an alternative to [Ch 4, 1.1 Scope 1.1.2](#), C and C-Mn steel castings and alloy steel castings which comply with National or proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this Chapter or alternatively are approved for a specific application. Generally, survey and certification are to be carried out in accordance with the requirements of [Ch 1 General Requirements](#).

1.2 Manufacture

1.2.3 Where two or more castings are joined by welding to form a composite item, details of the proposed welding procedure are to be submitted for approval. ~~Welding approval procedure tests will be required, see also the requirements of~~ [Ch 4, 1.11 Rectification and dressing of castings](#). The welding procedure and welders are to be qualified in accordance with [Ch 12 Welding Qualification](#).

1.2.4 Temporary welds made for operations such as lifting, handling, staging, etc. are to be in accordance with approved welding procedures and qualified welders, and are to be removed, ground, and inspected using suitable surface NDE methods. All temporary welds shall be recorded for traceability purposes.

1.4 Chemical composition

1.4.2 Except where otherwise specified in [Table 4.2.1 Chemical composition of ladle samples for carbon and carbon-manganese hull steel castings](#) and [Table 4.2.2 Chemical composition of ladle samples for alloy hull steel castings](#), suitable grain refining elements may be used at the discretion of the manufacturer and agreed with LR. The content of such elements is to be reported in the ladle analysis.

1.5 Heat treatment

1.5.3 As an alternative procedure to the connection of thermocouples as required by [Ch 4, 1.5 Heat treatment 1.5.2](#), temperature uniformity surveys of the heat treatment furnace may be accepted subject to approval by LR, Materials and NDE department. An initial temperature uniformity survey in the furnace fully loaded condition is required to be carried out in accordance with recognised standards (e.g. ASTM A991/A991M). Regular temperature uniformity surveys are then subsequently required at a frequency of at least once per year.

1.5.4 If a casting is locally reheated, or any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment may be required in order to avoid the possibility of harmful residual stresses. The manufacturer shall have strict control of this temperature in order to avoid any detrimental effects on the final heat treatment and resultant microstructure and mechanical properties of the casting.

1.6 Test material and test specimens

1.6.1 Test material sufficient for the tests specified in Sections [Ch 4, 2 Castings for ship and other structural applications](#) to [Ch 4, 9 Steel castings for container corner fittings](#) and for possible re-test purposes is to be provided for each casting. The size of the test samples for mechanical testing is to be such that the heat treatment and microstructure is representative of the ruling section of the casting, i.e., the section for which the specified mechanical properties apply (as referenced in ISO 683-1 and ISO 683-2). For C and C-Mn steel castings this is in general to be achieved as follows: The test samples are to be either integrally cast or gated to the castings and are to have a thickness (t_s) of not less than 30 mm, the ruling section of the casting, or 30 mm, whichever is larger.

1.6.2 For large thickness castings other than stern tube, stern frame, anchor and rudder horn, (t_s) does not normally need to exceed 150 mm. The length and width of the test sample is normally to be at least three times t_s , as shown in [Figure 4.1.1 Specimen position relative to test sample dimension taken as \(\$t_s\$ \) x \(\$3t_s\$ \) x \(\$3t_s\$ \) for section thickness greater than 56 mm](#), unless otherwise agreed with LR.

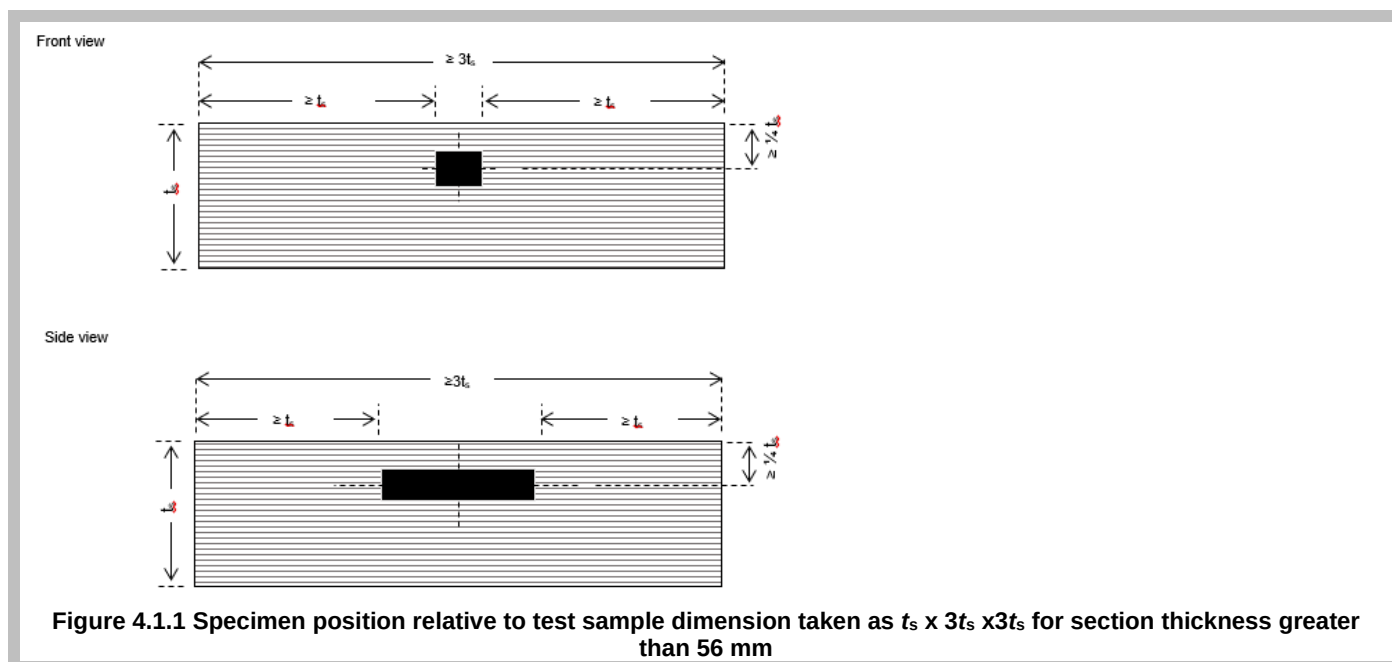
Longer or wider test samples may be necessary in order to accommodate the required test specimens. For castings for stern tubes, stern frames, anchors and rudder horns, the test sample thickness t_s shall represent the ruling section.

Note Shorter widths or lengths may be accepted for test samples where the actual casting width or length (t_A) is in the range between (t_s) and ($3t_s$).

Note 1. For a general casting with dimensions 140 x 160 x 1250 mm the required test sample size would typically be 140 x 160 x 420 mm (that is: $t_s \times t_A \times 3t_s$).

Note 2: For a stern tube casting with ruling section $t_s = 170$ mm and width/height/length $t_{A1}/t_{A2}/t_{A3} = 1000/600/1800$ mm, the required test sample size would typically be 170 x 510 x 510 mm (that is: $t_s \times 3t_s \times 3t_s$) see [Figure 4.1.2 Note 2: test sample gated to stern tube casting](#).

1.6.3 For alloy steel castings the manufacturer shall propose dimensions for the test sample and demonstrate that they are representative.



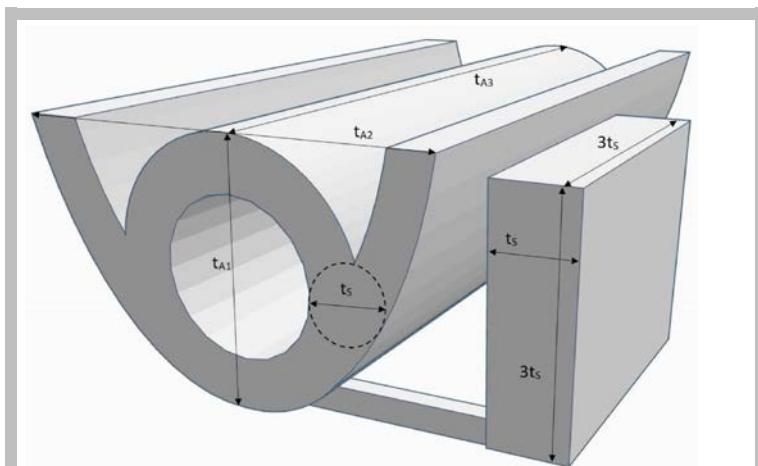


Figure 4.1.2 Note 2: test sample gated to stern tube casting

1.6.4 For test samples with thicknesses up to and including 56 mm, the longitudinal axis of the test specimens is to be located not lower than 14 mm from the surface in the thickness direction. For test samples with thicknesses greater than 56 mm, the longitudinal axis of the test specimens is to be located not lower than $\frac{1}{4} t_s$ from the surface in accordance with the requirements of ISO 4990. Test specimens shall be taken in such a way that no part of the gauge length is machined from material closer than t_s to any of the other surfaces. For impact testing, this requirement shall apply to the complete test specimen, see [Figure 4.1.1 Specimen position relative to test sample dimension taken as \$\(t_s\) \times \(3t_s\) \times \(3t_s\)\$ for section thickness greater than 56 mm](#) for location of test specimens in relation to the test sample.

~~1.6.2~~ 1.6.5 The test samples are not to be detached from the casting until the heat treatment specified in [Ch 4, 1.5 Heat treatment 1.5.1](#) has been completed and they have been properly identified.

~~1.6.3~~ 1.6.6 As an alternative to [Ch 4, 1.6 Test material and test specimens 1.6.1](#) and [Ch 4, 1.6 Test material and test specimens 1.6.25](#), where a number of small castings of about the same size, each of which is under 1000 kg in mass, are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted, using separately cast test samples of suitable dimensions. The test samples are to be properly identified and heat treated together with the castings which they represent. At least one test sample is to be provided for each batch of castings.

~~1.6.4~~ 1.6.7 The test specimens are to be prepared in accordance with the requirements of [Ch 2 Testing Procedures for Metallic Materials](#). One tensile test specimen and one set of impact tests are to be taken from each test sample. Tensile test specimens are to have a cross-sectional area of not less than 150 mm².

~~1.6.5~~ 1.6.8 Re-test procedures are to be in accordance with [Ch 2, 1.4 Re-testing procedures](#). The additional tests detailed in [Ch 2, 1.4 Re-testing procedures](#) are to be taken, preferably from the same test sample, but alternatively from another test sample representative of the casting or batch of castings.

1.11 Rectification and dressing of castings

1.11.1 Where castings are to be repaired, the manufacturer shall exercise robust controls of all repair operations regarding the repair of castings, with respect to dimensions, heat treatment, inspection and quality control.

~~1.11.1~~ 1.11.2 When unacceptable defects are found in a casting, these are to be removed by machining or chipping. Flame-scarfing or arc-air gouging may also be used provided that is employed when necessary and that the surfaces of the resulting excavation are subsequently ground smooth. Complete elimination of the defective material is to be proven by adequate non-destructive examination. Shallow grooves or excavations resulting from the removal of defects may, at the discretion of the Surveyor, be accepted provided that they will cause no appreciable reduction in the strength of the castings and that they are suitably blended by grinding. Complete elimination of the defective material is to be verified by magnetic particle or dye penetrant testing.

When unacceptable defects are found in a casting, these are to be removed by the following methods (or a combination of these methods):

- grinding,
- chipping,
- arc air-gouging,
- flame scarfing, or
- machining.

Where thermal methods of metal removal methods are used, e.g. flame-scarfing or arc-air gouging, preheating shall be used and the surfaces of the resulting excavation shall subsequently be ground smooth. Complete elimination of the defective material is to be proven by adequate non-destructive examination. All grooves shall have a bottom radius of approximately three times the groove depth and should be smoothly blended with the surface area with a finish equal to that of the adjacent surface. Shallow grooves or excavations resulting from the removal of defects may, at the discretion of the Surveyor, be accepted provided that they will cause no appreciable reduction in the strength of the castings or affect the intended use, and the depth of defect removal is not over 15 mm

or 10 per cent of wall thickness, whichever is less and that they are suitably blended by grinding. Complete elimination of the defective material is to be verified by magnetic particle or dye penetrant testing. Small surface irregularities sealed by welding are to be treated as weld repairs, see [Ch 4 1.11 Rectification and dressing of castings 1.11.5](#).

Existing paragraphs 1.11.2 to 1.11.3 have been renumbered 1.11.3 to 1.11.4.

~~1.11.4~~ **1.11.5** All proposals to repair a defective casting by welding are to be submitted to the Surveyor before this work is commenced. The Surveyor is to ~~satisfy himself~~ be satisfied that the number, position and size of the defects are such that the casting can be effectively repaired. The following apply for weld repairs:

- (a) For C and C-Mn steel castings, weld repairs shall be suitably classified as major or minor.
 - (i) Major repairs are those where:
 - the depth is greater than 25 per cent of the wall thickness or 25 mm whichever is less, or
 - the total weld area on a casting exceeds 0,125 m² of the casting surface noting that, where a distance between two welds is less than their average width, they are to be considered as one weld.
 - before welding is started, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted for approval.
 - (ii) Minor weld repairs: Weld repairs not classified as major are considered as minor. LR may request minor repairs in critical areas to be treated as major repairs.
- (b) For alloy steel castings, all repairs require approval from LR.
- (c) After major and minor repairs are completed, the appropriate heat treatment is to be carried out, See also [Ch 4, 1.11 Rectification and dressing of castings 1.11.13](#).

Existing paragraph 1.11.5 has been renumbered 1.11.6.

~~1.11.6~~ **1.11.7** Welding procedures are to be qualified and shall match the final heat treatment of the casting. All welding is to be carried out by an approved welder and in accordance with an approved welding procedure which includes the features referred to in [Ch 4, 1.9 Rectification and dressing of castings 1.9.6](#) to [Ch 4, 1.9 Rectification and dressing of castings 1.9.13](#). The welding procedures and welders are to be qualified in accordance with [Ch 12 Welding Qualifications](#) and witnessed by the Surveyor.

Note:

For welding steels with a carbon content (taken as a percentage of chemical composition) not lower than 0,23 or Ceq not lower than 0,45, the WPQT (welding procedure qualification test) on which the WPS is based, should be qualified on a base material having a Ceq as follows: the Ceq of the base material should not fall below more than 0,02 of the material to be welded. (Example: WPQT for a material with actual Ceq = 0,50 may be qualified on a material with Ceq not lower than 0,48.)

Existing paragraphs 1.11.7 to 1.11.11 have been 1.11.8 to 1.11.12.

~~1.11.12~~ **1.11.13** After a welding repair is completed, the castings are to be given the heat treatment specified in [Ch 4, 2 Castings for ship and other structural applications](#) to [Ch 4, 9 Steel castings for container corner fittings](#), or a stress relieving heat treatment at a temperature of not less than 550 °C for C and C-Mn steel castings. For alloy steel castings, the heat treatment is to be agreed with LR. The type of heat treatment required will be dependent on the chemical composition of the casting and the dimensions, positions and nature of the repairs, and should not be detrimental to the properties of the casting.

Existing paragraph 1.11.13 has been renumbered 1.11.14.

~~1.11.14~~ **1.11.15** On completion of heat treatment, all welds and adjacent material are to be ground smooth and examined by magnetic particle or penetrant testing, ~~ultrasonic or radiographic examination~~. Supplementary examination by ultrasonic or radiographic testing may also be required depending on the dimensions and nature of the original defect. The Surveyor is to attend at these inspections, to witness the results of magnetic particle or penetrant examination and to examine any radiographs. Satisfactory results are to be obtained from all forms of Non-Destructive Examination used. The acceptance criteria for the NDE of welds are to be in accordance with subsequent Sections of this Chapter or where these do not exist, [Table 13.2.5 Acceptance criteria for visual testing, magnetic particle and liquid penetrant testing](#) to [Table 13.2.7 Acceptance criteria for ultrasonic and phased array testing](#), as appropriate.

Existing paragraphs 1.11.15 to 1.11.17 have been renumbered 1.11.16 to 1.11.18.

■ Section 2 Castings for ship and other structural applications

2.1 Scope

2.1.1 These requirements are for carbon, carbon-manganese and alloy steel castings, intended for ship for worldwide service and other structural applications, ~~where the design and acceptance tests are related to mechanical properties at ambient temperature, are given in this Section~~. The requirements also consider grades that are intended for fabrication by welding, as well as grades not intended for welding.

2.2 Chemical composition

2.2.1 The chemical composition of ladle samples is to comply with [Table 4.2.1 Chemical composition of ladle samples for carbon and carbon-manganese hull steel castings](#) and [Table 4.2.2 Chemical composition of ladle samples for alloy hull steel castings](#).

Table 4.2.1 Chemical composition of ladle samples for carbon and carbon-manganese hull steel castings

Chemical element Quality grade	Quality grade		
	Normal grade		Special grade (See Notes 3 and 4)
	Castings for welded construction	Castings for non-welded construction	
Carbon	0,23% max.	0,40% max.	0,23% max.
Silicon	0,60% max.	0,60% max.	0,60% max.
Manganese	0,70-0,50-1,60%	0,50-1,60%	0,70-1,60%
Sulphur	0,040-0,035% max.	0,035% max.	0,035% max.
Phosphorus	0,040-0,035% max.	0,035% max.	0,035% max.
Aluminium- (Acid soluble)	-	-	0,015-0,080% (see Notes 1 and 2)
Residual elements:			
Copper	0,30% max.	0,30% max.	0,30% max.
Chromium	0,30% max.	0,30% max.	0,30% max.
Nickel	0,40% max.	0,40% max.	0,40% max.
Molybdenum	0,15% max.	0,15% max.	0,15% max.
Total	0,80% max.	0,80% max.	0,80% max.
Note 1. The total aluminium content may be determined instead of the acid soluble content, in which case the total aluminium content is to be 0,020 – 0,10%. Note 2. Grain refining elements other than aluminium may be used subject to special agreement with LR. Note 3. For the Special grade, the nitrogen content is to be determined. Note 4. Special grade is also applicable to castings for welded construction.			

2.2.3 For the Special grade, a check chemical analysis on the product or a test bar is mandatory. The check analysis on the product or test bar is to comply with the requirements of [Table 4.2.1 Chemical composition of ladle samples for carbon and carbon-manganese hull steel castings](#).

Table 4.2.2 Chemical composition of ladle samples for alloy hull steel castings

Chemical element	Applications	
	Castings for welded construction	Castings for non-welded construction
Carbon		0,45% max.
Silicon		0,60 & max.
Manganese		0,50-1,60%
Sulphur		0,030% max.
Phosphorus		0,035% max.
Residual elements (See Note):		
Copper	Alloying element values are to comply with recognised national/ international standards or designer's specifications and shall be agreed with LR	0,30% min.
Chromium		0,40% min.
Nickel		0,40% min.
Molybdenum		0,15% min.

Total		-
Note. At least one of the elements shall comply with the minimum content.		

2.3 Heat treatment

2.3.3 Following ~~weld repair and~~ the attachment of handling brackets, all castings are to be subject to post weld heat treatment at a temperature of not less than 550°C before delivery.

2.4 Mechanical tests and properties

2.4.2 Where the casting is of complex design, or where the finished mass exceeds 10 tonnes, two ~~cast on~~ test samples are to be provided from the heaviest section, located as far as practicable from each other. Where large castings are made from two or more casts which are not mixed in a ladle prior to pouring, two or more test samples are required corresponding to the number of casts involved. These are to be integrally cast at locations as widely separated as possible.

2.4.3 The results of these tensile tests are to comply with the following requirements: provided in [Table 4.2.3 Mechanical properties for hull steel castings intended for welding](#) and [Table 4.2.4 Mechanical properties for hull steel castings not intended for welding](#).

Yield stress	200 N/mm ² min.
Tensile strength	400 N/mm ² min.
Elongation on $5.65\sqrt{S_0}$	25% min.
Reduction of area	40% min.

Table 4.2.3 Mechanical properties for hull steel castings intended for welding

Steel type	Specified minimum tensile strength (N/mm ²)	Yield stress (N/mm ²) min.	Elongation on $5.65\sqrt{S_0}$ (%) min.	Reduction of area (%) min.	Charpy V-notch impact test (See Note)	
					Test temperature (°C)	Minimum average energy (J)
C, C-Mn	400-550	200	25	40	0	27
	440-590	220	22	30		
	480-630	240	20	27		
	520-670	260	18	25		
	560-710	300	15	20		
	600-750	320	13	20		
Alloy	550-700	355	18	30		
	600-750	400	16	30		
	650-800	450	14	30		
	700-850	540	12	28		

Note: Special consideration may be given to alternative requirements for Charpy V-notch impact test, depending on design and application, and subject to agreement by LR.

Table 4.2.4 Mechanical properties for hull steel castings not intended for welding

Steel type	Specified minimum tensile strength (N/mm ²)	Yield stress (N/mm ²) min.	Elongation on $5.65\sqrt{S_0}$ (%) min.	Reduction of area (%) min.	Charpy V-notch impact test (See Note 1)	
					Test temperature (°C)	Minimum average energy (J)
C, C-Mn	400-550	200	25	40	AT (See Note 2)	27
	440-590	220	22	30		
	480-630	240	20	27		
	520-670	260	18	25		
	560-710	300	15	20		
	600-750	320	13	20		
Alloy	550-700	340	16	35		
	600-750	400	16	35		
	650-800	450	14	32		
	700-850	540	12	28		

Note 1. Special consideration may be given to alternative requirements for Charpy V-notch impact test, depending on design and application, and subject to agreement by LR.

Note 2. AT refers to Ambient Temperature (i.e. 23°C±5°C), which is specified in ISO 148-1.

Existing paragraph 2.4.4 has been deleted.

2.6 Acceptance levels for Non-Destructive Examination of castings

2.6.3 The following quality levels recommended for magnetic particle testing (MT) and/or liquid penetrant testing (PT) are:

- (a) Level MT1/PT1 – fabrication weld preparation areas.
- (b) Level MT2/PT2 – other locations indicated on [Figure 4.2.1 Extent of non-destructive evaluation for stern frame castings](#) to [Figure 4.2.6 Extent of non-destructive evaluation for rudder \(lower part\) castings](#).

The allowable number and sizes of indications in the reference area are shown in the acceptance criteria detailed in [Table 4.2.25 Acceptance criteria for surface inspection evaluation](#). Cracks, cold shuts and hot tears are not acceptable.

2.6.4 Acceptance criteria for ultrasonic testing are shown in [Table 4.2.36 Ultrasonic Acceptance Criteria for steel castings – Using DGS or DAC system](#) as UT1 and UT2. Discontinuities within the examined zones interpreted to be cracks, cold shuts or hot tears are not acceptable.

(Figure not shown in proposal)

Figure 4.2.7 DAC curve produced from 6 mm FBH reflector and DAC curves adjusted to represent equivalent 12 mm and 15 mm FBH reflectors

Explanatory note for DAC and Figure 4.2.7

- The bottom curve (DAC) represents a sensitivity based on 6 mm FBH, and the two additional curves (DAC + 12 dB and DAC + 16 dB) above this represent the equivalent sensitivities converted for larger FBHs (12 mm and 15 mm).
- When scanning using these curves and applying [Table 4.2.35 Ultrasonic Acceptance Criteria for steel castings – Using DGS or DAC system](#) for UT2, any indication below DAC + 12 dB is to be disregarded, and any indication above DAC + 16 dB is to be rejected.

Any indication between these two curves is to be evaluated according to its size, as per [Table 4.2.36 Ultrasonic Acceptance Criteria for steel castings – Using DGS or DAC system](#).

Existing tables 4.2.2 to 4.2.3 have been renumbered 4.2.5 to 4.2.6.

■ Section 3 Castings for machinery construction

3.1 Scope

3.1.1 This Section gives the material requirements for carbon, carbon-manganese and alloy steel castings intended for use in machinery construction and which are not within the scope of [Ch 4, 4 Castings for crankshafts](#) to [Ch 4, 7 Ferritic steel castings for low temperature service](#).

3.1.2 Where it is proposed to use steels of higher carbon content than is indicated in [Ch 4, 3.2 Chemical composition 3.2.1 Table 4.3.1 Chemical composition limits for machinery steel castings \(%\): C, C-Mn steels](#) or [Table 4.3.2 Chemical composition limits for machinery steel castings \(%\): Alloy steels](#), or alloy steels, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval.

3.2 Chemical composition

3.2.1 The chemical composition of ladle samples for carbon and carbon-manganese machinery steel castings is to comply with the following limits, except as specified in [Ch 4, 3.2 Chemical composition 3.2.2](#): given in [Table 4.3.1 Chemical composition limits for hull and machinery steel castings \(%\): C, C-Mn steels](#), or where applicable, the requirements of the approved specification.

Carbon	0,40% max.
Silicon	0,60% max.
Manganese	0,50-1,60%
Sulphur	0,040% max.

Phosphorus 0,040% max.

Residual elements:

- Copper 0,30% max.
- Chromium 0,30% max.
- Nickel 0,40% max.
- Molybdenum 0,15% max.
- - Total 0,80% max.

Table 4.3.1 Chemical composition limits for machinery steel castings (%): C, C-Mn steels

Steel type	Applications	C (max.)	Si (max.)	Mn	S (max.)	P (max.)	Residual elements (max.)				Total residuals (max.)
							Cu	Cr	Ni	Mo	
C, C-Mn	Castings for non-welded construction	0,40	0,60	0,50-1,60	0,035	0,035	0,30	0,30	0,40	0,15	0,80
	Castings for welded construction	0,23 (See Note)	0,60	0,50-1,60	0,035	0,035	0,30	0,30	0,40	0,15	0,80
Note. Castings which are intended for parts of a welded fabrication are to be of weldable quality with a carbon content generally not exceeding 0,23%. The carbon content may be increased above this level provided that the carbon equivalent (Ceq) is not more than 0,41%, calculated using the following formula: $Ceq = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15} \text{ (%)}$											

Existing paragraph 3.2.2 has been deleted.

Existing paragraph 3.2.3 has been renumbered 3.2.2.

3.2.3 For alloy machinery steel castings, the chemical composition of the ladle samples is to comply with the limits provided in [Table 4.3.2 Chemical composition limits for machinery steel castings \(%\): Alloy steels](#), or where applicable, the requirements of the approved specification.

Table 4.3.2 Chemical composition limits for machinery steel castings (%): Alloy steels

Steel type	Applications	C (max.)	Si (max.)	Mn	S (max.)	P (max.)	Alloying elements (min.) (See Note)			
							Cu	Cr	Ni	Mo
Alloy	Castings for non-welded construction	0,45	0,60	0,50-1,60	0,030	0,035	0,30	0,40	0,40	0,15
	Castings for welded construction	Alloying element values are to comply with recognised national/ international standards or designer's specifications and shall be agreed with LR.								
Note. At least one of the elements shall comply with the minimum content.										

3.3 Heat treatment

3.3.1 Castings are to be supplied in one of the following delivery conditions:

- (a) ~~fully annealed; or~~
- (b) ~~normalised; or~~
- (c) ~~normalised and tempered at a temperature of not less than 550°C; or~~
- (d) ~~quenched and tempered at a temperature of not less than 550°C.~~

(a) Carbon and carbon-manganese steels:

- Fully annealed
- Normalised
- Normalised and tempered
- Quenched and tempered.

(b) Alloy steels:

- Normalised
- Normalised and tempered
- Quenched and tempered

For all types of steel, the tempering temperature is to be not less than 550°C.

3.3.2 The delivery condition shall meet the design and application requirements. It is the manufacturer's responsibility to select the appropriate heat treatment method for obtaining the required mechanical properties.

Existing paragraph 3.3.2 has been renumbered 3.3.3.

3.4 Mechanical tests

3.4.1 At least one tensile test specimen is and one set of impact tests are to be made on taken from material representing each casting or batch of castings.

3.4.2 Where the casting is of complex design, or where the finished mass exceeds 10 tonnes, two cast on test samples are to be provided from the heaviest section, located as far as practicable from each other. Where large castings are made from two or more casts which are not mixed in a ladle prior to pouring, two or more test samples are required corresponding to the number of casts involved. The test samples are to be integrally cast at locations as widely separated as possible.

3.4.3 ~~Table 4.3.1 Mechanical properties for acceptance purposes: carbon and carbon-manganese steel castings for machinery construction~~ Table 4.3.3 Mechanical properties for steel castings intended for welding and Table 4.3.4 Mechanical properties for machinery steel castings not intended for welding gives the minimum requirements for yield stress, elongation, and reduction of area and impact test energy values corresponding to steel types and different strength levels, but it is not intended that these should necessarily be regarded as specific grades. Intermediate levels of minimum tensile strength may be specified, in which case minimum values for yield stress, elongation and reduction of area may be obtained by interpolation.

Existing Table 4.3.1 Mechanical properties for acceptance purposes: carbon and carbon-manganese steel castings for machinery construction has been deleted.

Table 4.3.3 Mechanical properties for machinery steel castings intended for welding

Steel type	Specified minimum tensile strength (N/mm ²)	Yield stress (N/mm ²) min.	Elongation on 5, $65\sqrt{S_0}$ (%) min.	Reduction of area (%) min.	Charpy V-notch impact test (See Note)	
					Test temperature (°C)	Minimum average energy (J)
C, C-Mn	400-550	200	25	40	0	27
	440-590	220	22	30		
	480-630	240	20	27		
	520-670	260	18	25		
	560-710	300	15	20		
	600-750	320	13	20		
Alloy	550-700	355	18	30		
	600-750	400	16	30		
	650-800	450	14	30		
	700-850	540	12	28		

Note. Special consideration may be given to alternative requirements for Charpy V-notch impact test, depending on design and application, and subject to agreement by LR.

Table 4.3.4 Mechanical properties for machinery steel castings not intended for welding

Steel type	Specified minimum tensile strength (N/mm ²)	Yield stress (N/mm ²) min.	Elongation on 5, $65\sqrt{S_0}$ (%) min.	Reduction of area (%) min.	Charpy V-notch impact test (See Note 1)	
					Test temperature (°C)	Minimum average energy (J)
C, C-Mn	400-550	200	25	40	AT (See Note 2)	27
	440-590	220	22	30		
	480-630	240	20	27		
	520-670	260	18	25		
	560-710	300	15	20		
	600-750	320	13	20		

Alloy	550-700	340	16	35		
	600-750	400	16	35		
	650-800	450	14	32		
	700-850	540	12	28		
Note 1. Special consideration may be given to alternative requirements for Charpy V-notch impact test, depending on design and application, and subject to agreement by LR.						
Note 2. AT refers to Ambient Temperature (i.e. 23°C±5°C), which is specified in ISO 148-1.						

3.4.4 Castings may be supplied to any specified minimum tensile strength selected within the general limits detailed in [Table 4.3.1 Mechanical properties for acceptance purposes: carbon and carbon-manganese steel castings for machinery construction](#) [Table 4.3.3 Mechanical properties for steel castings intended for welding](#) and [Table 4.3.4 Mechanical properties for machinery steel castings not intended for welding](#) respectively, but are subject to any additional requirements of the relevant construction rules.

3.4.5 The results of all tensile mechanical tests are to comply with the requirements of [Table 4.3.1 Mechanical properties for acceptance purposes: carbon and carbon-manganese steel castings for machinery construction](#) [Table 4.3.3 Mechanical properties for steel castings intended for welding](#) and [Table 4.3.4 Mechanical properties for machinery steel castings not intended for welding](#) respectively, appropriate to the specified minimum tensile strength or, where applicable, the requirements of the approved specification.

3.4.7 When a casting, or a batch of castings, has failed to meet the mechanical test requirements, it may be re-heat treated and re-submitted for acceptance tests but this may not be carried out more than twice, see [Ch 1, 4.6 Re-test procedures](#) [Ch 2, 1.4 Re-testing procedures](#). The additional tests detailed in [Ch 2, 1.4 Re-testing procedures](#) are to be taken, preferably from the same test sample, but alternatively from another test sample representative of the casting or batch of castings.

■ Section 4

Castings for crankshafts

4.3 Chemical composition

4.3.1 The chemical composition of ladle samples is to comply with the following limits: provided in [Table 4.4.1 Chemical composition limits for steel castings for crankshafts \(%\): C, C-Mn steels](#).

Carbon	- 0,40% max. (~~but see Ch 4, 4.7 Rectification of defective castings 4.7.4.(c)~~)
Silicon	- 0,60% max.
Manganese	- 0,50-1,60%
Sulphur	- 0,040% max.
Phosphorus	- 0,040% max.
Residual elements:	
- Copper	- 0,30% max.
- Chromium	- 0,30% max.
- Nickel	- 0,40% max.
- Molybdenum	- 0,15% max.
- -	- Total 0,80% max.

Table 4.4.1 Chemical composition limits for steel castings for crankshafts (%): C, C-Mn steels

Steel type	C (max.)	Si (max.)	Mn	S (max.)	P (max.)	Residual elements (max.)				Total residuals (max.)
						Cu	Cr	Ni	Mo	
C, C-Mn	0,40 see Note	0,60	0,50-1,60	0,035	0,035	0,30	0,30	0,40	0,15	0,80

Note. See [Ch 4, 4.7 Rectification of defective castings 4.7.4.\(c\)](#).

4.5 Mechanical tests

4.5.3 [4.4.12 Mechanical properties for acceptance purposes: carbon - manganese steel castings for crankshafts](#) gives the minimum requirements for yield stress and elongation corresponding to different strength levels, and it is not intended that these

should necessarily be regarded as specific grades. The strength levels have been given in multiples of 40 N/mm² to facilitate interpolation for intermediate values of specified minimum tensile strength.

4.5.4 Castings may be supplied to any specified minimum tensile strength selected within the general limits detailed in [Table 4.4.12 Mechanical properties for acceptance purposes: carbon - manganese steel castings for crankshafts](#).

4.5.5 The results of all tests are to comply with the requirements of [Table 4.4.12 Mechanical properties for acceptance purposes: carbon - manganese steel castings for crankshafts](#) appropriate to the specified minimum tensile strength. For the impact tests, one individual value may be less than the required average value provided that it is not less than 70 per cent of this average value. See [Ch 1, 4.6 Re-test procedures](#) for re-test procedures.

(Part only shown)

Table 4.4.1 4.4.2 Mechanical properties for acceptance purposes: carbon - manganese steel castings for crankshafts

Tensile strength N/mm ²	Yield stress N/mm ² minimum	Elongation on 5.65√ <i>S_o</i> % minimum	Charpy V-notch impact tests average energy J minimum (See Note)
Note. Impact tests are to be made at ambient temperature (i.e. 23°C±5°C), which is specified in ISO 148-1.			

■ Section 8 Stainless steel castings

8.1 Scope

8.1.1 This Section gives the requirements for castings in austenitic and duplex stainless steels for machinery, marine structures, and piping systems in ships for liquefied gases, and in bulk chemical tankers.

8.1.2 Austenitic stainless steels castings are suitable for applications where the lowest design temperature is not lower than – 165°C.

8.1.3 Duplex stainless steels castings are suitable for applications where the lowest design temperature is not lower than -20°C above 0°C. Any requirement to use duplex stainless steels castings below 0°C will be subject to special consideration.

8.4 Mechanical tests

(Part only shown)

Table 4.8.2 Mechanical properties for acceptance purposes: austenitic stainless steel castings

Type of steel	Tensile strength N/mm ² minimum	1,0% proof stress N/mm ² minimum	Elongation on 5,65√ <i>S</i> ₀ % minimum	Reduction of area % minimum	Charpy V-notch impact test	
					Test temperature °C	Average energy J minimum
Duplex						
UNS J 92205 (see Note 1)	600	420	20	35	0 (see Note 2)	41
Note 1. The grade UNS J 92205 is the cast equivalent of UNS S 31803.						
Note 2. Charpy V-notch impact tests are to be carried out at a temperature 5°C below design temperature or 0°C, whichever is lower.						

8.4.2 The tensile test is to be carried out at ambient temperature, and the results are to comply with the requirements given in [Table 4.8.2 Mechanical properties for acceptance purposes: austenitic stainless steel castings](#).

8.4.3 The average value for impact test specimens is to comply with the appropriate requirements given in [Table 4.8.2 Mechanical properties for acceptance purposes: austenitic stainless steel castings](#). One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value. See [Ch 2, 1.4 Re-testing procedures](#) for re-test procedures.

Chapter 5

Steel Forgings

■ Section 1

General requirements

1.1 Scope

Existing paragraphs 1.1.4 to 1.1.6 have been deleted.

Existing paragraph 1.1.7 has been renumbered 1.1.4.

1.2 Manufacture

1.2.1 Forgings are to be made at works which have been approved by Lloyd's Register (hereinafter referred to as LR). The steel used is to be manufactured in accordance with the requirements of the [Rules for the Manufacture, Testing and Certification of Materials, Ch 3, 1.4 Manufacture](#). Where the steel is produced at a separate works to the forging, the steel manufacturer is also to be approved by LR.

1.2.14 Where two or more forgings are joined by welding to form a composite component, details of the proposed welding procedure are to be submitted for approval. Welding approval procedure tests ~~may~~ are to be required in accordance with [Rules for the Manufacture, Testing and Certification of Materials, Ch 12, Welding Qualifications](#).

1.4 Chemical composition

1.4.3 For alloy steel forgings, the chemical composition of ladle samples is to ~~generally comply with the following overall limits and the requirements of~~ [Table 5.2.1 Chemical composition limits for hull steel forgings](#) and [Table 5.3.1 Chemical composition limits for machinery steel forgings](#). ~~the approved specifications.~~ Chemical compositions contained in alternative standards will be specially considered for their intended application.

~~Carbon~~	~~0,45% max.~~
~~Silicon~~	~~0,45% max.~~
~~Manganese~~	~~0,30% min.~~
~~Sulphur~~	~~0,035% max.~~
~~Phosphorus~~	~~0,035% max.~~
~~Copper~~	~~0,30% max.~~

~~And at least one of the following elements to comply with the minimum content:~~

~~Chromium~~	~~0,40% min.~~
~~Molybdenum~~	~~0,15% min.~~
~~Nickel~~	~~0,40% min.~~

~~The contents of all alloying elements and significant impurities detailed in the specification are to be reported.~~

1.5 Heat treatment

1.5.3 As an alternative procedure to the connection of thermocouples as required by [Ch 5, 1.5 Heat treatment 1.5.2](#), temperature uniformity surveys of the heat treatment furnace may be accepted subject to approval by LR, Materials and NDE department. An initial temperature uniformity survey in the furnace fully loaded condition is required to be carried out in accordance with recognised standards (e.g. ASTM A991/A991M). Regular temperature uniformity surveys are then subsequently required at a frequency of at least once per year.

1.5.6 If any straightening operation is performed after the final heat treatment, consideration should be given to a subsequent stress relieving heat treatment in order to avoid the possibility of harmful residual stresses. The manufacturer shall have strict control of the stress relieving heat treatment temperature in order to avoid any detrimental effects on the final heat treatment and the resultant microstructure and mechanical properties of the forging.

1.6 Test material

1.6.4 Where a number of small forgings of about the same size are made from one cast and heat treated together in the same furnace, batch testing procedures (~~see Ch 5, 1.1 Scope 1.1.4~~) may be adopted using one of the forgings for test purposes, or alternatively using separately forged test samples. These test samples are to have a forging reduction similar to that used for the

forgings which they represent. They are to be properly identified and heat treated together with the forgings. Unless otherwise agreed the maximum allowable batch size is to be as follows:

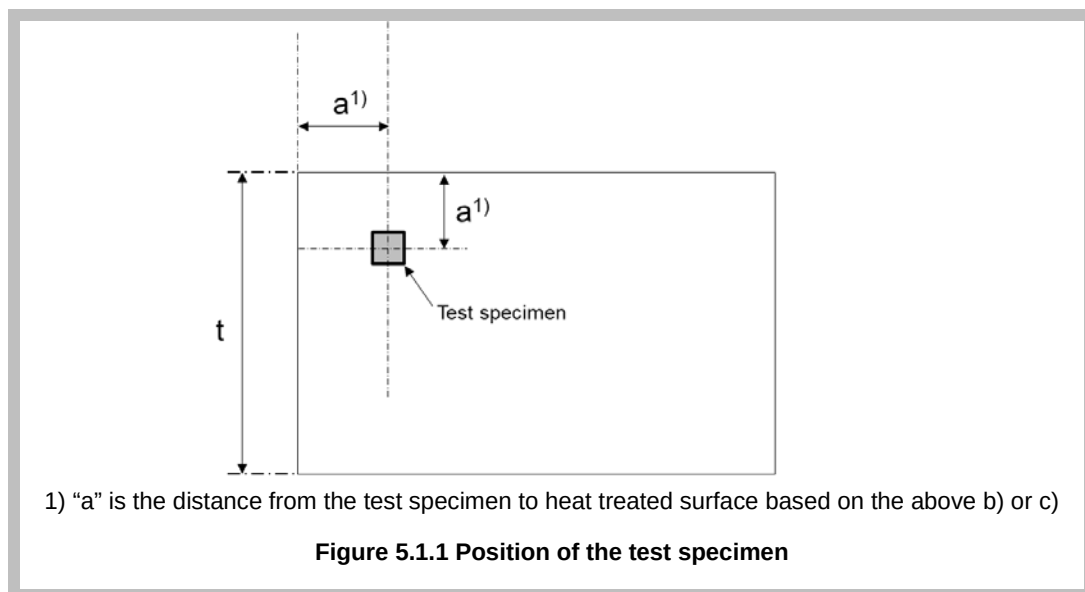
- (a) Normalised forgings with mass up to 1000 kg each may be batch tested. A batch is to consist of forgings of similar shape and dimensions, made from the same steel-making heat, heat treated together and with a total mass not exceeding 6 tonnes.
- (b) Quenched and tempered forgings with mass up to 500 kg each may be batch tested. A batch is to consist of forgings of similar shape and dimensions, made from the same steel-making heat, heat treated together in the same furnace and with a total mass not exceeding 3 tonnes.
- (c) A batch testing procedure may also be used for hot rolled bars, see [Ch 5, 3.4 Mechanical tests 3.4.3](#).

1.7 Mechanical tests

1.7.3 Unless otherwise agreed, the longitudinal axis of the The test specimens is to shall be positioned as follows:

- (a) ~~for thickness or diameter ≤ 50 mm, the axis is to be at the mid-thickness or the centre of the cross section;~~ For forgings with a thickness, t , or diameter D up to a maximum 50 mm, the longitudinal axis of the test specimen is to be located at a distance of $t/2$ or $D/2$ below the heat-treated surfaces.
- (b) ~~for thickness or diameter > 50 mm, the axis is to be at one quarter thickness (mid-radius) or 80 mm, whichever is less, below any heat treated surface;~~ For forgings with a thickness, t , or diameter D greater than 50 mm, the longitudinal axis of the test specimen is to be located at a distance of $t/4$ or $D/4$ (mid-radius) or 80 mm, whichever is less, below any heat-treated surface. Test specimen is to be located with its longitudinal axis at a distance from any heat-treated surface as shown in [Figure 5.1.1 Position of the test specimen](#).
- (c) For ring and disc forgings (note that the test specimen locations for these shaped forgings may be different to elongated or free from forgings), tangential samples shall be taken at $t/2$ for thickness ≤ 25 mm and 12,5 mm below the surface for thickness greater than 25 mm, in both the vertical and horizontal directions as shown in [Figure 5.1.1 Position of the test specimen](#).

Test pieces shall be taken in such a way that no part of the gauge length is machined from material closer than 12,5 mm to any heat treated surface. For impact testing, this requirement is to apply to the complete test piece. Where achievable, for thickness greater than 25 mm, no part of the test material shall be closer than 12,5 mm to any heat-treated surface, as shown in [Figure 5.1.1 Position of the test specimen](#).



1.7.4 Where the manufacturer can demonstrate that a proposed testing location or orientation is more representative of the required mechanical properties of a component, this may be agreed with LR. In such cases, the heat treatment process, a proposed testing location or orientation, and technical justification, shall be submitted to LR for approval.

Existing paragraphs 1.7.4 to 1.7.7 have been renumbered 1.7.5 to 1.7.8

1.8 Visual and Non-Destructive Examination

1.8.1 ~~Before acceptance, all forgings are to be presented to the Surveyor for visual examination. Where applicable, this is to include the examination of internal surfaces and bores.~~ All forgings should be subjected to a 100 per cent visual examination of all accessible surfaces by the manufacturer and the results of these examinations made available to the Surveyor. Where applicable, this visual examination is to include the examination of internal surfaces and bores. Unless otherwise agreed, the verification of dimensions is the responsibility of the manufacturer.

Existing paragraph 1.8.11 has been deleted.

Existing paragraphs 1.8.12 to 1.8.19 have been renumbered 1.8.11 to 1.8.18.

1.10 Identification

(Part only shown)

1.10.2 Forgings are to be clearly marked by the manufacturer in accordance with the requirements of [Ch 1 General Requirements](#). The following details are to be shown on all forgings which have been accepted:

- (a) Manufacturer's name or trademark, steel quality, materials grade, identification number, cast number or other marking which will enable the full history of the forging to be traced.

1.11 Certification of materials

(Part only shown)

1.11.2 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each forging or batch of forgings which has been accepted:

- (e) General details of heat treatment, including temperature and holding times.
(h) Results of non-destructive tests, where applicable.

■ Section 2 Forgings for ship and other structural applications

2.2 Chemical composition

2.2.1 For forgings to which structural items are to be attached by welding or which are intended for parts of a fabricated component, or are to be weld cladded or may be subject to weld repair in service, the chemical composition of ladle samples is to comply with the following [Table 5.2.1 Chemical composition limits for hull steel forgings](#):

Carbon	0,23% max.
Silicon	0,45% max.
Manganese	0,30 – 1,50% but not less than 3 times the actual carbon content for components which are not given a post-weld heat treatment
Sulphur	0,035% max.
Phosphorus	0,035% max.
Residual elements:	
- Copper	0,30% max.
- Chromium	0,30% max.
- Molybdenum	0,15% max.
- Nickel	0,40% max.
- Total	0,85% max.

For samples from forgings, the carbon content is not to exceed 0,26 per cent.

Table 5.2.1 Chemical composition limits for hull steel forgings

Steel type	Composition in percentage mass by mass maximum unless shown as a range									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu See Note 2	Total residuals
C, C-Mn	0,23 Max. See Note 1	0,45 Max.	0,30-1,50	0,035 Max.	0,035 Max.	0,30 Max. See Note 2	0,15 Max. See Note 2	0,40 Max. See Note 2	0,30 Max.	0,85 Max.
Alloy See Note 4	Note 3	0,45 Max.	Note 3	0,035 Max.	0,035 Max.	Note 3	Note 3	Note 3	0,30 Max.	-

Note 1: The carbon content may be increased above this level provided that the carbon equivalent (Ceq) is not more than 0,41%, calculated using the following formula:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15} (\%)$$

Note 2: Elements are considered as residual elements.

Note 3: Specification is to be submitted for approval.

Note 4: The contents of all alloying elements and significant impurities detailed in the specification are to be reported.

2.2.2 It is recommended that forgings for rudder stocks, pintles and rudder coupling bolts comply with [Ch 5, 2.2 Chemical composition, 2.2.1 Table 5.2.1 Chemical composition limits for hull steel forgings](#) in order to obtain satisfactory weldability for any future repairs by welding in service.

2.2.3 For C and C-Mn steel forgings not intended for welding welded construction, the carbon content may be 0,65 per cent maximum., see [Ch 5, 3.2 Chemical composition 3.2.1.](#)

2.2.4 Where alloy steel forgings are intended for welded constructions, the proposed chemical composition is subject to approval by LR.

2.3 Heat treatment

2.3.1 ~~Carbon manganese steel forgings are to be:~~

- ~~(a) fully annealed; or~~
- ~~(b) normalised; or~~
- ~~(c) normalised and tempered at a temperature of not less than 550°C.~~
- ~~(d) quenched and tempered.~~

2.3.1 Forgings are to be supplied in one of the following conditions:

(a) Carbon and carbon-manganese steels:

- Fully annealed.
- Normalised.
- Normalised and tempered.
- Quenched and tempered.

(b) Alloy steels:

- Normalised.
- Normalised and tempered.
- Quenched and tempered.

For all types of steel, the tempering temperature is to be not less than 550°C.

2.3.2 ~~Alloy steel forgings are to be quenched and then tempered at a temperature of not less than 550°C. Alternatively, they may be supplied in the normalised and tempered condition, in which case the specified mechanical properties are to be agreed by LR.~~ The delivery condition shall meet the design and application requirements. It is the manufacturer's responsibility to select the appropriate heat treatment method to obtain the required mechanical properties.

2.4 Mechanical tests

2.4.1 At least one tensile specimen is to be taken from each forging or batch of forgings. The Charpy V-notch impact tests are to be in accordance with the requirements of [Table 5.2.2 Mechanical properties for ship and other structural applications](#).

2.4.4 The results of all tensile tests are to comply with the requirements given in [Table 5.2.12 Mechanical properties for ship and other structural applications](#) appropriate to the specified minimum tensile strength. Forgings may be supplied to any specified minimum tensile strength within the general limits given in [Table 5.2.12 Mechanical properties for ship and other structural applications](#), and intermediate values may be obtained by interpolation. See [Ch 5, 2.4 Mechanical tests 2.4.6](#) for rudder stocks, pintles, and rudder coupling keys and bolts.

Existing Table 5.2.1. has been renumbered 5.2.2 and replaced with below:

Table 5.2.2 Mechanical properties for ship and other structural applications

Steel type	Tensile strength R _m min. N/mm ²	Yield stress R _e min. N/mm ²	Elongation A ₅ min. %		Reduction of area Z min. %		Charpy V-notch impact test See Notes 1 & 2		
			Long.	Tang.	Long.	Tang.	Test temperature (°C)	Minimum average energy (J)	
								Long.	Tang.
C and C-Mn	360-480	180	28	20	50	35	0	27	18
	400-520	200	26	19	50	35			
	440-560	220	24	18	50	35			
	470-590	235	23	17	45	35			
	480-600	240	22	16	45	30			
	520-640	260	21	15	45	30			

Alloy	560-680	280	20	14	40	27			
	600-750	300	18	13	40	27			
	550-670	350	20	14	50	35			
	600-750	400	18	13	50	35			
	650-800	450	17	12	50	35			

Note 1. Special consideration may be given to alternative requirements for Charpy V-notch test, depending on design and application, and subject to agreement by LR.

Note 2. For ships with ice class notation: Impact tests are required for rudder stocks intended for ships with ice class notation 1AS FS(+), IAS FS, 1A FS(+), 1A FS, 1B FS(+), 1B FS, 1C FS(+) and 1C FS. The tests are to be carried out for all steel types at minus 10°C and the average energy value is to be minimum 20J (longitudinal test). One individual value may be less than the required average value provided that it is not less than 70% of this average value.

Existing paragraph 2.4.7 has been deleted.

2.5 ~~Non-destructive examination~~ Destructive Examination

2.5.4 The allowable number and size of indications in the reference area is given in [Table 5.2.23 Steel forgings surface inspection](#).

Existing Table 5.2.2 has been renumbered Table 5.2.3.

■ Section 3 Forgings for shafting and machinery

3.2 Chemical composition

3.2.1 The chemical composition of ladle samples for carbon ~~and~~, carbon-manganese ~~and~~ alloy steels is to comply with the following overall limits provided in [Table 5.3.1 Chemical composition limits for machinery steel forgings](#):

Carbon	~~0,65% max.~~
Silicon	~~0,45% max.~~
Manganese	~~0,30-1,50%~~
Sulphur	~~0,035% max.~~
Phosphorus	~~0,035% max.~~
Residual elements:	
- Copper	~~0,30% max.~~
- Chromium	~~0,30% max.~~
- Molybdenum	~~0,15% max.~~
- Nickel	~~0,40% max.~~
- Total	~~0,85% max.~~

Table 5.3.1 Chemical composition limits for machinery steel forgings

Steel type	Composition in percentage mass by mass maximum, minimum, or a range as shown									
	C	Si	Mn	P	S	Cr See Note 3	Mo See Note 3	Ni See Note 3	Cu See Note 3	Total residuals
C, C-Mn	0,23 Max. See Notes 1 & 2	0,45 Max.	0,30- 1,50 See Note 6	0,035 Max.	0,035 Max.	0,3 Max.	0,15 Max.	0,40 Max.	0,30 Max.	0,85 Max.
Alloy See Note 4	0,45 Max.	0,45 Max.	0,30- 1,00	0,035 Max.	0,035 Max.	0,40 Min. See Note 5	0,15 Min. See Note 5	0,40 Min. See Note 5	0,30 Max.	-

Note 1. For welded components, the carbon content of C and C-Mn steel forgings may be increased above 0,23% maximum, provided that the carbon equivalent (Ceq) is not more than 0,41%, calculated using the following formula:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15} (\%)$$

Note 2 The carbon content of C and C-Mn steel forgings not intended for welded construction may be 0,65 maximum.

Note 3 Elements are considered as residual elements unless shown as a minimum.

Note 4 Where alloy steel forgings are intended for welded constructions, the proposed chemical composition is subject to approval by LR.

Note 5 For alloy steel forgings, one or more of the elements is to comply with the minimum content.

Note 6 For C and C-Mn steel forgings, the Manganese content is not less than 3 times the actual carbon content for components which are not given a post-weld heat treatment.

Existing paragraph 3.2.2 has been deleted.

~~3.2.3~~ 3.2.2 For forgings to which structural items are to be attached by welding, or which are intended for parts of a fabricated component, are to be of weldable quality, see [Ch 5, 2.2 Chemical composition-2.2.1 Table 5.2.1 Chemical composition limits for hull steel forgings](#).

3.3 Heat treatment

3.3.2 The delivery condition shall meet the design and application requirements. It is the manufacturers responsibility to select the appropriate heat treatment method to obtain the required mechanical properties.

3.4 Mechanical tests

3.4.1 At least one tensile test is to be made on each forging, or each batch of forgings. ~~The Charpy V-notch impact tests are not required except on screwshafts for ice service, see~~ [Ch 5, 3.4 Mechanical tests 3.4.12](#) are to be in accordance with the requirements of [Table 5.3.2 Mechanical properties for acceptance purposes: carbon, carbon-manganese and alloy steel forgings for machinery and shafting](#).

3.4.4 The test specimens are to be taken in the longitudinal direction but, at the discretion of the manufacturer and if agreed by the Surveyor, alternative directions or positions as shown in [Figs. Figure 5.3.1 Directions and positions of test specimens, Figure 5.3.2 Directions and positions of test specimens](#), and [Figure 5.3.3 Directions and positions of test specimens](#) may be used.

For forged rings (e.g. slewing rings), one set of tests is to be taken from each forging in a tangential direction (test positions are shown in [Figure 5.3.4 Directions and positions of test specimens for forged rings](#)). Where the finished diameter exceeds 2500 mm or the mass (as heat treated, including test material) exceeds 3 tonnes then two sets of tests are to be taken at diametrically opposite positions.

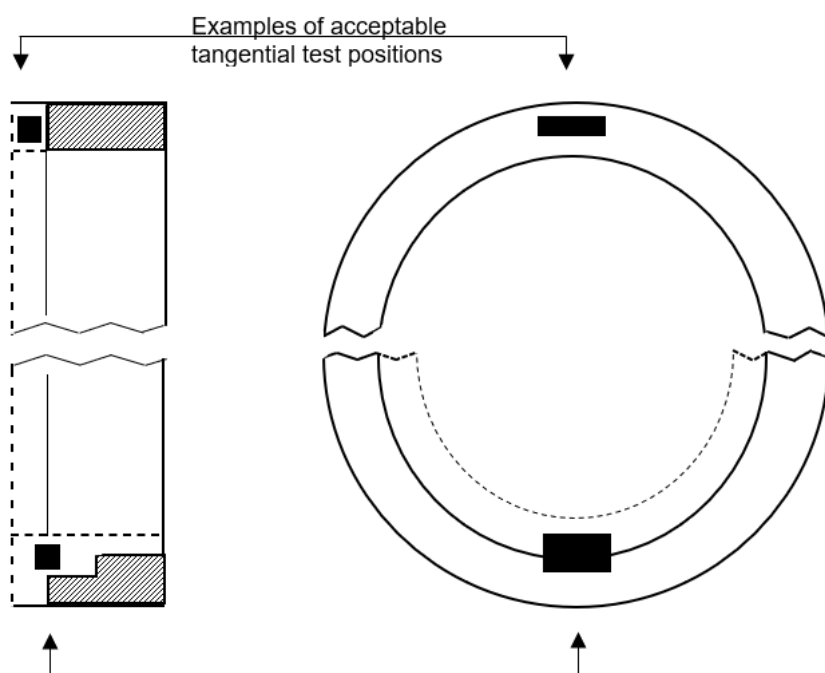


Figure 5.3.4 Directions and positions of test specimens for forged rings

3.4.5 For carbon, carbon-manganese and alloy steels, [Table 5.3.12 Mechanical properties for acceptance purposes: carbon, and carbon-manganese and alloy steel forgings for machinery and shafting](#) gives the minimum requirements for yield stress, elongation, and reduction of area, and typical Brinell hardness values, corresponding to different strength levels, but it is not intended that these should necessarily be regarded as specific grades. Intermediate values for other specified minimum tensile strengths should be calculated by interpolation.

3.4.6 Forgings may be supplied to any specified minimum tensile strength selected within the general limits detailed in [Table 5.3.12 Mechanical properties for acceptance purposes: carbon, and carbon-manganese and alloy steel forgings for machinery and shafting](#), except that for main propulsion shafting forgings the specified minimum tensile strength is to be as defined in the relevant Rules dealing with design.

Existing Table 5.3.1. has been renumbered Table 5.3.2 and replaced with below:

Table 5.3.2 Mechanical properties for acceptance purposes: carbon, carbon-manganese and alloy steel forgings for machinery and shafting

Steel type	Tensile strength R_m min. N/mm ²	Yield stress R_e min. N/mm ²	Elongation A_5 min. %		Reduction of area Z min. %		Hardness See Note 1 (Brinell)	Charpy V-notch impact test See Notes 2 & 3		
								Test temperature (°C)	Minimum average energy (J)	
			Long.	Tang.	Long.	Tang.			Long.	Tang.
C and C-Mn	360-480	180	28	20	50	35	-	AT See Note 4	27	18
	400-550	200	26	19	50	35	110-150			
	440-590	220	24	18	50	35	125-160			
	480-630	240	22	16	45	30	135-175			
	520-670	260	21	15	45	30	150-185			
	560-710	280	20	14	40	27	160-200			
	600-750	300	18	13	40	27	175-215			
	640-790	320	17	12	40	27	185-230			
	680-830	340	16	12	35	24	200-240			
	720-870	360	15	11	35	24	210-250			
	760-910	380	14	10	35	24	225-265			
Alloy	600-750	360	18	14	50	35	175-215			
	700-850	420	16	12	45	30	205-245			
	800-950	480	14	10	40	27	235-275			
	900-1100	630	13	9	40	27	260-320			
	1000-1200	700	12	8	35	24	290-365			
	1100-1300	770	11	7	35	24	320-385			

Note 1. The hardness values are typical and are given for information purposes only.

Note 2. Special consideration may be given to alternative requirements for Charpy V-notch test, depending on design and application, and subject to agreement by LR.

Note 3. For ships with ice class notation: Materials used for machinery exposed to sea water temperature, such as screwshafts, propeller shafts and shaft bolts, intended for ships with ice class notation 1AS FS(+), IAS FS, 1A FS(+), 1A FS, 1B FS(+), 1B FS, 1C FS(+) and 1C FS. Charpy V-notch impact testing is to be carried out for all steel types at -10°C and the average energy value is to be minimum 20J (longitudinal test). One individual value may be less than the required average value provided that it is not less than 70% of this average value.

Note 4. AT refers to Ambient Temperature (i.e. 23°C±5°C), which is specified in ISO 148-1.

3.4.7 The results of all tensile mechanical tests are to comply with the requirements given in [Table 5.3.12 Mechanical properties for acceptance purposes: carbon, and carbon-manganese and alloy steel forgings for machinery and shafting](#) appropriate to the specified minimum tensile strength.

Existing paragraph 3.4.8 has been deleted.

Table 5.3.2 Mechanical properties for acceptance purposes: alloy steel forgings for machinery and shafting has been deleted.

Existing paragraphs 3.4.9 and 3.4.10 has been deleted.

Existing paragraph 3.4.11 has been renumbered 3.4.8.

Existing paragraph 3.4.12 has been deleted.

3.5 Non-Destructive Examination

Existing Figures 5.3.4 to 5.3.7 have been renumbered 5.3.5 to 5.3.8

Figure 5.3.45 Zones for magnetic particle/liquid penetrant testing on shaft machinery components

3.5.3 The areas to be tested by magnetic particle or liquid penetrant testing are shown in [Figure 5.3.45 Zones for magnetic particle/liquid penetrant testing on shaft machinery components](#) and [Figure 5.3.56 Zones for magnetic particle/liquid penetrant testing on machinery components](#). Areas of other components not shown in these figures are to be agreed with the Surveyor. For tie rods, only threaded portions and the adjacent material over a length equal to that of the thread need be tested.

(Part only shown)

3.5.5 Ultrasonic testing is to be carried out in accordance with [Ch 5, 2.5 Non-destructive examination](#) on the following items unless otherwise agreed with LR:

The areas to be tested are shown in [Figure 5.3.67 Zones for ultrasonic testing on shafts](#) and [Figure 5.3.78 Zones for ultrasonic testing on machinery components](#). Areas of other components not shown in these drawings are to be agreed with the Surveyor.

■ Section 5 Forgings for gearing

5.4 Heat treatment

5.4.2 The delivery condition shall meet the design and application requirements. It is the manufacturers responsibility to select the appropriate heat treatment method to obtain the required mechanical properties. Where forgings for gearing are not intended for surface hardening, lower tempering temperatures may be allowed.

Existing paragraphs 5.4.2 to 5.4.5 have been renumbered 5.4.3 to 5.4.6.

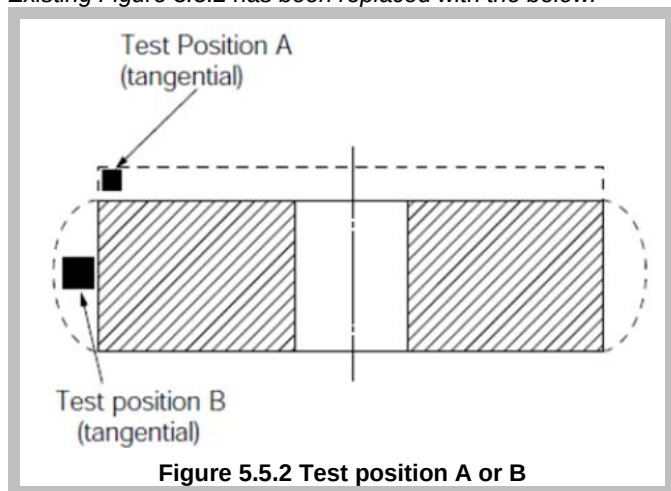
5.5 Mechanical tests for through hardened, induction hardened or nitrided forgings

(Part only shown)

5.5.1 At least one tensile test specimen is to be taken from each forging in carbon or carbon-manganese steel, and at least one tensile specimen from forgings in alloy steel. Sufficient test material is to be provided for this purpose and the test specimens are to be taken as follows:

- (c) For gear wheel forgings, tests are to be taken from each forging in a tangential direction (from one of the test positions A or B in [Figure 5.5.2 Test Position A or B](#)).
- (d) For gear wheel rim forgings, tests are to be taken in a tangential direction (from one of the test positions A in [Figure 5.5.3 Test position A](#)). Where the finished diameter exceeds 2500 mm or the mass (as heat treated but ~~excluding~~ including test material) exceeds 3 tonnes, tests are to be taken from two diametrically opposite positions (test positions A in [Figure 5.5.3 Test position A](#)).
- (f) For forged rings, the directions and positions of the set of tests to be taken from each ring are to comply with the requirements of [Ch 5, 3 Forgings for shafting and machinery 3.4.4](#).

Existing Figure 5.5.2 has been replaced with the below:



■ Section 9 Stainless steel forgings

9.1 General

9.1.1 Forgings in austenitic and duplex stainless steels are acceptable for use in the construction of cargo tanks, storage tanks and piping systems for chemicals and liquefied gases marine structures, machinery, pressure vessels and piping systems in ships. They may also be accepted for elevated temperature service in boilers.

9.1.2 Where it is proposed to use forgings in these types of steels, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval. These are to comply, in general, with the requirements of [Ch 3, 7 Austenitic and duplex stainless steels](#) for austenitic steel plates. Austenitic stainless steel forgings are suitable for applications where the design temperature is not lower than -165°C.

9.1.3 Austenitic stainless steels are also suitable for service at elevated temperatures. Forgings for such applications are to comply with the requirement of [Ch 5, Table 5.9.1 Chemical composition of stainless steel forgings](#) and the requirement of [Ch 5, 9.5 Mechanical properties for design purposes](#).

9.1.4 Duplex stainless steels forgings are suitable for applications where the design temperature is not lower than -20°C.

9.1.5 Where it is proposed to use alternative steels, particulars of the specified chemical composition, mechanical properties and heat treatment are to be submitted for approval.

Existing paragraph 9.1.3 has been renumbered 9.1.6.

9.4 Mechanical tests

(Part only shown)

Table 5.9.2 Mechanical properties for acceptance purposes: stainless steel forgings

Type of steel	Tensile strength N/mm ² minimum	1,0% proof stress N/mm ² minimum	Elongation on 5,65√S _o % minimum	Reduction of area % minimum	Charpy V-notch impact tests	
					Test temperature °C	Average energy J
Duplex						
UNS S 31803	620	450	25	45	-20 (see Note)	41
UNS S 32750	800	550	15	40		
Note Charpy V-notch impact tests are to be carried out at a temperature 5°C below design temperature or -20°C, whichever is lower.						

Chapter 6 Steel Pipes and Tubes

■ Section 1 General requirements

1.1 Scope

1.1.4 Steels intended for the pressure piping systems for liquefied gases where the use of steels with guaranteed impact properties at low temperatures is required the design temperature is less than 0°C are to comply with the specific requirements of [Ch 6, 4 Ferritic steel pressure pipes for low temperature service](#) or [Ch 6, 5 Stainless steel pressure pipes](#).

■ Section 4

Ferritic steel pressure pipes for low temperature service

4.4 Mechanical tests

(Part only shown)

Table 6.4.2 Mechanical properties for acceptance purposes

Type of steel	Grade	Yield stress N/mm ²	Tensile strength N/mm ²	Elongation on $5,65\sqrt{S_0}$ % minimum	Flattening test constant C	Bending test diameter of former (t=thickness)	Charpy V-notch impact tests	
							Test temperature °C	Average energy J minimum
Carbon	360	210	360-480	24	0,10	4t	-40	27
Carbon-manganese	410	235	410-530	22	0,08	4t	-50 -60 (see note)	27
	460	260	460-580	21	0,07			

Note: The test temperature for carbon-manganese steels may be 5°C below the design temperature if the latter is above -55°C, with a maximum test temperature of -20°C.

Note For standard subsidiary impact test specimens, the minimum energy values are to be as follows:

Required average energy value for standard 10 mm x 10 mm	Subsidiary 10 mm x 7,5 mm	Subsidiary 10 mm x 5 mm
	Average energy	Average energy
27J	22J	18J
34J	28J	23J
41J	34J	27J

■ Section 5

Stainless steel pressure pipes

5.1 Scope

5.1.1 Provision is made in this Section for austenitic and duplex stainless steel pipes suitable for use in the construction of the piping systems for ships, chemicals and for liquefied gases where the design temperature is not less than minus 165°C and for bulk chemical tankers.

5.1.2 Austenitic stainless steels forgings are suitable for applications where the design temperature is not lower than -165°C.

Existing paragraph 5.1.2 has been renumbered 5.1.3.

Existing paragraph 5.1.3 has been deleted.

5.1.4 Duplex stainless steels are suitable for applications where the design temperature is not lower than -20°C.

5.4 Mechanical tests

5.4.2 Each pipe selected for test is to be subjected to tensile and flattening or bend tests and, where the wall thickness is 6 mm or greater, Charpy impact tests shall be performed at the test temperatures specified in [Table 6.5.2 Mechanical properties for acceptance purposes](#).

(Part only shown)

Table 6.5.2 Mechanical properties for acceptance purposes

Type of steel	Grade	0,2% proof stress N/mm ² (see see Note 1)	1,0% proof stress N/mm ²	Tensile strength N/mm ²	Elongation on 5,65√S ₀ % minimum	Flattening test constant C	Bend test diameter of former (t=thickness)	Charpy V-notch impact tests	
								Test temperature °C	Average energy J
Austenitic									
304L									
316L									

317								-196	41	
321										
347										
Duplex										
UNS S31803								-20 (see Note 2)	41	
UNS S32750										
Note 1 Except for the duplex stainless steel grades, the 0,2% proof stress values are given for information purposes and unless otherwise agreed are not required to be verified by test.										
Note 2 Charpy V-notch impact tests are to be carried out at a temperature 5°C below design temperature or -20°C, whichever is lower.										

Chapter 9 Copper Alloys

■ Section 1 Castings for propellers

1.8 Inspection and non-destructive examination

1.8.18 Where it is suspected that a casting contains internal defects, or where deemed necessary by the manufacturer or Surveyor, further volumetric NDE should be carried out, where practical, in the form of radiographic and/or ultrasonic testing. The acceptance criteria are to be agreed between the manufacturer and LR in accordance with a recognised standard. The standard ASTM E272-99 (Severity Level 2) or equivalent is to be the radiographic acceptance standard for copper alloy castings.

Chapter 10 Equipment for Mooring and Anchoring

■ Section 1 Anchors

1.1 Scope

1.1.3 In the context of this Section, the reference to swivels and swivel shackles refers to those directly attached to the anchor shank in lieu of the conventional 'D' shackle. For other mooring equipment swivels, see [Ch 10, 2.13 Fittings for chain cables](#).

1.2 Design requirements

1.2.1 All anchors including their accessories are to be of an approved design. For any separate accessories not part of the approved design, see [Ch 10, 2.13 Fittings for chain cables](#). In addition, HHP and SHHP anchor designs including their accessories are required to be tested in accordance with [Ch 10, 1.3 Anchor holding power tests for HHP and SHHP anchors](#) so as to confirm the holding power.

1.4 Cast steel anchors

1.4.1 Cast steel anchor heads, shanks, shackles, and swivels and swivel shackles are to be manufactured and tested in accordance with the requirements of [Ch 4, 1 General requirements](#) and [Ch 4, 2 Castings for ship and other structural applications](#). The Special grade quality is to be used for anchor heads, shanks and shackles.

1.4.2 Swivel and swivel shackles shall be manufactured to at least Grade U2. Special consideration will be given to the use of other grades of steel for the manufacture of swivels.

1.5 Forged steel anchors

1.5.1 Forged steel anchor pins, swivels, shanks, and shackles and swivel shackles are to be manufactured and tested in accordance with the requirements of [Ch 5, 1 General requirements](#) and [Ch 5, 2 Forgings for ship and other structural applications](#) carbon and carbon-manganese steel for welded construction. Rolled steel bar may be used provided that the requirements of [Ch 5, 1.2 Manufacture 1.2.9](#) are met.

1.5.2 Swivel and swivel shackles shall be manufactured to at least Grade U2. Special consideration will be given to other grades of steel for the manufacture of swivels.

1.9 Assembly

1.9.1 Assembly and fitting, including any accessories, is to be carried out in accordance with the approved design.

1.9.2 Securing of anchor pins, shackle pins, or swivels or swivel shackles by welding is to be carried out by suitably qualified welders in accordance with an approved welding procedure.

1.10 Proof test of anchors

1.10.4 The general arrangements for the test are to be such that the complete anchor, including the shackle, shackle pins, swivel or swivel shackle and any welded or bolted connections are included in the test. If a replacement shackle, swivel or swivel shackle is needed which requires welding or heating for fitting, the combined anchor and shackle accessories are to be proof load tested. If welding or heating is not involved in fitting, the shackle accessories may be proof load tested separately from the anchor.

1.11 Clearances and tolerances

1.11.6 Unless otherwise agreed, the verification of mass and dimensions is the responsibility of the manufacturer. The Surveyor is only required to monitor this inspection. The mass of the anchor is to exclude the mass of the swivel or swivel shackle, unless the swivel or swivel shackle is in lieu of the conventional 'D' shackle.

■ Section 2 Stud link chain cable for ships

2.13 Fittings for chain cables

2.13.8 All chain cable accessories, including spares, are to be subjected to the proof loads appropriate to the grade and size of cable for which they are intended. These include shackles, swivels, swivel shackles, enlarged links and end links. Where swivel shackles are not permanently attached as part of an approved anchor design, then they shall be design approved and tested as a chain cable fitting. Anchor shackles, including D shackles and swivel shackles, which are permanently attached to an anchor shank, however, are also to be tested in combination with the anchor assembly in accordance with the approved design, see [Ch 10, 1.2 Design requirements](#).

Chapter 12 Welding Qualifications

■ Section 2 Welding procedure qualification tests for steels

2.7 Destructive tests for steel butt welds

(Part only shown)

2.7.13 Hardness surveys:

- (a) A Vickers hardness survey is to be performed on the macro specimen taken from the weld start end of the test assembly in accordance with that shown in [Figure 12.2.14 Hardness testing locations for butt welds](#), using a test load not in excess of 10 kg. For each row of indents, there are to be a minimum of 3 individual indentations in the weld metal, the heat affected zones (both sides), the base metal (both sides), and in addition, 2 indentations are required in the grain coarsened heat affected zone,

one above and one below the hardness survey row. The recommended distance between indents is 1,0 mm, but the distance between indents should not be less than the minimum specified in ISO 6507-1-1.

■ *Section 4* **Welding procedure tests for non-ferrous alloys**

4.1 Requirements for aluminium alloys

Table 12.4.1 Acceptance criteria for surface imperfections of aluminium alloys

Note 1. To be in accordance with EN-ISO 10042.

■ *Section 7* **Welding qualification requirements for high strength steel for special marine applications**

7.4 Welding procedure qualification tests

7.4.6 The Charpy V-notch impact fracture appearance is to be determined in accordance with ISO 148-1: ~~Metallic materials — Charpy pendulum impact test — Part 1: Test method~~ or another recognised National Standard.

Chapter 13 **Requirements for Welded Construction**

■ *Section 4* **Specific requirements for fusion welded pressure vessels**

4.5 General requirements for routine weld production tests

4.5.2 Routine production test plates are required during the manufacture of vessels, and as part of the initial approval test programme for Class 1 vessel manufacturers, refer to ~~MQPS-0-4~~.

4.12 Non-Destructive Examination of welds

4.12.2 NDE is not to be applied until an interval of at least 48 hours has elapsed since the completion of welding. This requirement may be waived at the discretion of the Surveyor where post-weld heat treatment is carried out.

■ *Section 8* **Specific requirements for welded aluminium**

8.4 Non-Destructive Examination

8.4.1 The requirements of [Ch 13, 1.11 Non-destructive examination of welds](#) and [Ch 13, 2.12 Non-destructive examination of steel welds](#) apply with the following additional provisions;
b. The acceptance criteria for surface imperfections of aluminium welds are to be in accordance with [Table 13.8.3 Radiographic acceptance criteria for internal imperfections of aluminium](#) [Table 13.8.2 Acceptance criteria for surface imperfections of aluminum](#).

Table 13.8.2 Acceptance criteria for surface imperfections of aluminium

Note 2. To be in accordance with EN-ISO 10042.

Chapter 14

Plastics Materials and other Non-Metallic Materials

■ Section 2

Tests on polymers, resins, reinforcements and associated materials

2.14 Plywoods

2.14.2 For structural applications in the marine environment, a minimum timber rating of moderate durability according to BS 1088-1 and BS 1088-2 is required.

■ Section 3

Testing procedures

3.7 Tests for specific materials

Table 14.3.2 Tests on unreinforced cast thermoset resin specimens

Note 1. ISO 62:2008 – where resins are intended for use under ambient conditions to avoid additional post-curing, the requirement in ISO 62:2008 for pre-drying the test specimen at 50°C is to be omitted. The test result is to be expressed as mg of water.

Note 2. ISO 527-2:1993 – tensile properties are to be measured using extensometry.

Table 14.3.3 Tests on laminate specimens

Note 1. ISO 62:2008 – where resins are intended for use under ambient conditions to avoid additional post-curing, the requirement in ISO 62:2008 for pre-drying the test specimen at 50°C is to be omitted. The test result is to be expressed as mg of water.

Note 2. ISO 527-4:1997 – tensile properties are to be measured using extensometry.

3.9 Machinery chocking compounds

(Part only shown)

Table 14.3.5 Tests for machinery chocking components

Test	Standard
Barcol hardness	ASTM D2583 or BS-EN 59

Chapter 15

Corrosion Prevention

■ Section 2

Coatings

2.10 Anti-fouling coatings

2.10.1 Coatings used on the hulls of LR classed vessels shall be recognised by LR as complying with the IMO Convention on the Control of Harmful Anti-fouling Systems on Ships, and associated guidelines.

2.10.2 Compliance of a coating shall be demonstrated prior to use by the issue of a certificate of recognition, or alternatively by the sampling of the coating during or immediately after application. Coating samples shall be tested for their organotin controlled substances content and confirmed as being compliant before the vessel is issued with its AFS convention certificate.

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